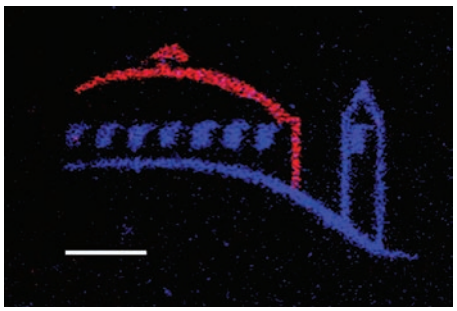
ALS Users' Meeting and Workshops

Novel Approaches to Soft X-ray Spectroscopy: Scanning Transmission X-ray Microscopy and Ambient Pressure X-ray Photoelectron Spectroscopy

This workshop focused on novel spectroscopies at Beamlines 11.0.2, 5.3.2 and 9.3.2 at the ALS. The workshop brought together users from a wide range of fields to highlight recent experimental and technical developments both in scanning transmission X-ray spectroscopy (STXM) and ambient pressure photoelectron spectroscopy (APPES). The morning session, organized by Mary K. Gilles (Berkeley Lab) and Tolek Tyliszczak (ALS), featured talks on experiments involving new developments at the STXM, while the afternoon session, organized by Hendrik Bluhm (Berkeley Lab) and Simon Mun (ALS), was devoted to those using APXPS.

In the morning session, Tolek Tyliszczak discussed the improved detector developments at the STXM, such as an avalanche photodiode detector and fluorescence and electron detection, as well as the continued development of in situ cells for heating, gas flow, and electrochemical cells. Of these, only the avalanche photodiode [implemented by Hermann Stoll (Max-Planck-Institut für Metallforschung, Stuttgart) and Tolek Tyliszczak] in combination with a novel multichannel photon-counting system designed by Yves Acremann (SSRL) is in routine use in time-resolved studies.



Berkeley Lab logo written in a polymer bilayer by STXM. Blue color represents selective radiation damage in polyacrylonitrile (written/read at 286.8 eV), while the red color represents selective radiation damage in polymethylmethacrylate (written/read at 288.5 eV). Scale bar is 2 microns.

Bartel Van Waeyenberge (Ghent University) presented results of magnetic imaging with a time resolution of 70–100 ps combined with a lateral resolution of 20–40 nm performed with the STXM (Beamline 11.0.2). As a complement to the time-domain "pump-and-probe" measurements, they developed a frequency-domain "sine-excitation" technique in order to study specific eigenmodes of these ferromagnetic patterns with high spatial resolution. This new approach was used to study the gyrotropic vortex motions in micron-sized ferromagnetic patterns.

Adam Hitchcock (McMaster University) presented the development, in collaboration with Daniel Guay (INRS, Varennes) and Sherry Zhang (a former postdoctoral associate), of the apparatus and techniques for applying STXM to in-situ studies of electrochemistry, in particular electrochromism in polyaniline. In addition, substantial progress was reported on a joint project with Harald Stöver (McMaster University) and PhD student Jian Wang to develop substrates and methods for chemically selective lithography of multilayer polymer systems. Selective patterns, such as that displayed in the figure, can now be written efficiently with the bend magnet STXM on Beamline 5.3.2.

Yves Acremann (SSRL) discussed time and spatially resolved X-ray magnetic circular dichroism (XMCD) experiments on spin transfer devices at the STXM (Beamline 11.0.2). These elegant experiments explore time resolved measurements of the magnetization dynamics within a 100×150 nm sample influenced by a spin-polarized current. This experiment shows that the magnetization in these magnetic nanostructures are not uniform, as they are influenced by the Oersted field of the charge current needed to generate the spin current. The implementation of a novel multichannel photon counting system in combination with an avalanche photon detector decreased the data-acquisition time by a factor of 10, owing to its ability to resolve the structure of multi bunch mode.

Gordon E. Brown, Jr. (Stanford University and SSRL) described "Applications of STXM to Microbial Bioweathering and Biomineralization." In the interaction of bacteria with ferrihydrite nanoparticles, microenvironments that were very different than the bulk material were observed, showing that bulk thermodynamics may not be useful for predicting micro phases. Gordon also presented work showing that iron nanoparticles are attracted to the negatively charged bacteria and form a coating that reduces iron oxide minerals.

The afternoon session started with presentations by Simon Mun and Hendrik Bluhm, who discussed the current status and the future plans for the two APPES end-stations at the ALS, which are located at Beamlines 9.3.2 and 11.0.2, respectively. In both end-stations, samples can be measured in gaseous environments at pressures of up to several Torr, which makes possible the investigation of numerous phenomena, in particular in the fields of atmospheric and environmental science as well as heterogeneous catalysis. Specific examples of the application of APPES were shown in the following presentations.

John Hemminger (University of California, Irvine) reported on APPES investigations at Beamlines 9.3.2 and 11.0.2 of the interaction of alkali halide surfaces with water. The measurements showed that upon deliquescense (when a layer of saturated solution is formed on the salt surface), the larger, more polarizable anions occupy the solution/vapor interface, which has great implications for the reactivity of, e.g., sea salt aerosols.

Guido Ketteler (Berkeley Lab) showed results of APPES experiments on the adsorption of water on metal oxide surfaces, in particular on TiO_2(110) and α-Fe_2O_3(0001), at ambient temperatures and under Torr pressures. Both surfaces are important substrates in environmental science, and the measurements revealed that already at relative humidities below 1%, molecular water is present at these surfaces.

Klas Andersson (SSRL and Stockholm University) then presented the results of APPES measurements of water adsorption on metal surfaces, also under ambient conditions. These investigations showed that the adsorption of water on copper(110) and (111) shows strong differences. The observations in these molecular scale investigations might help to explain macroscopic phenomena, such as the differences in the wetting of copper(110) and (111) by water.

Spiros Zafeiratos (Fritz Haber Institute of the Max Planck Society, Berlin) reported on the application of a dedicated APPES instrument at BESSY to the investigation of heterogeneous catalytic reactions. The apparatus is optimized for the investigation of realistic catalysts (e.g., powders) and uses a number of different methods for the simultaneous measurement of the gas-phase composition during the APPES experiments, which allows one to correlate the properties of the catalyst surface with its catalytic activity.

Yoshiharu Enta (Hirosaki University) presented APPES investigations of two types of surface reactions, silicon homoepitaxial growth and silicon oxidation. From measurement at various oxygen pressures and sample temperatures, the oxidation rate below one-monolayer oxide coverage of the silicon surface can be explained by an autocatalytic reaction model.

The last talk of the workshop was given by Dennis Nordlund (SSRL), who presented core-hole decay spectroscopy measurements of atom-site-specific electron delocalization rates in water and ice. He also discussed the design of a new APPES system that is under construction at SSRL. ■

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Soft and Hard X-ray Tomography at the ALS

A day-and-a-half-long workshop on soft and hard X-ray tomography was held as part of the 2005 ALS Users' Meeting. Many more participants than expected turned up, indicating the growth in interest in the technique, and unfortunately resulting in many participants having to sit on the floor!

The workshop opened with the organizers Alastair McDowell and Gerry McDermott (Berkeley Lab) giving overviews of the tomography capabilities at the ALS in the hard and soft X-ray ranges, respectively. This was followed by a comprehensive history of tomography at synchrotron sources by John Kinney (Lawrence Livermore National Laboratory). Marco Stampanoni (Paul Scherrer Institute) then discussed the latest developments in micro- and nano-imaging at the Swiss Light Source.

After a short break, Henry Chapman (Lawrence Livermore National Laboratory) gave an illuminating talk on the prospect of coherent diffraction imaging at a resolution of 10 nm. Given that this technique does not rely